

Research Report 1424

Information Requirements for Battlefield Management System: Survey and Prototype Evaluation

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U. S. Army

Research Institute for the Behavioral and Social Sciences

June 1986

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARI Research Report 1424	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) INFORMATION REQUIREMENTS FOR BATTLEFIELD MANAGEMENT SYSTEM: SURVEY AND PROTOTYPE EVALUATION	5. TYPE OF REPORT & PERIOD COVERED Final Report January 1985-June 1985	
	6. PERFORMING ORG. REPORT NUMBER ---	
7. AUTHOR(s) Jared B. Jobe	8. CONTRACT OR GRANT NUMBER(s) ---	
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Knox Field Unit Steele Hall, Fort Knox, KY 40121	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q263743A794 ✓	
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue, Alexandria, VA 22333-5600	12. REPORT DATE June 1986	
	13. NUMBER OF PAGES 45	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) ---	15. SECURITY CLASS. (of this report) Unclassified	
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE ---	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) ---		
18. SUPPLEMENTARY NOTES ---		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Command and control Battlefield information User requirements Graphic portrayal Armored Vehicle SMI Map information Human factors engineering BMS		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) → Two survey projects that evaluated information requirements for platoon leaders, platoon sergeants, and wingmen for a Battlefield Management System are reported. In Survey I, 30 armor officers and NCOs rated 34 information items on the basis of their necessity for mission accomplishment. Ratings were compared to the ratings of a group of four subject matter experts (SMEs). Results indi- cated that there was substantial agreement among raters for (Continued)		

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Information requirements for the three duty positions and that there was substantial agreement between players and SMEs on the overall priorities. The information items common to top 10 ratings of both groups were (1) critical situation alert, (2) concept of operations, (3) heading reference/navigation, (4) call for fire, (5) command mission, and (6) reports (format).

In Survey II, 16 of the 30 players participated in a demonstration of a Texas Instruments prototype system that presented these BMS information items: (1) aided navigation, (2) friendly positions, (3) enemy positions, (4) fuel status, (5) ammo status, (6) warning sensors, and (7) equipment failure. Players rated the priority of the seven elements equally and indicated that they would like the information displayed in two clusters, tactical and logistical. Results are discussed in terms of their relationship to duty positions.

Keywords: Command and control systems, Human factors engineering, Armored vehicles.

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Battlefield Management System:
Survey and Prototype Evaluation**

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Department of the Army**

June 1986

**Army Project Number
2Q263743A794**

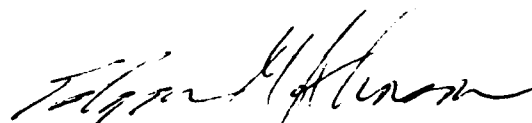
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FOREWORD

The Army Research Institute for the Behavioral and Social Sciences (ARI) is currently conducting research to determine the effects of future battlefield conditions on tank gunnery performance. As part of this effort, the Fort Knox Field Unit is conducting research to improve combat performance by providing selected information to commanders and crews. This report presents the results of two surveys evaluating information items of a Battlefield Management System (BMS) at the platoon level. Information items receiving high ranks in these experiments are potential candidates for a BMS system. The long-term goal of this research is to enhance soldier readiness by facilitating the soldier's capability to use future friendly weapons systems and by devising means to counter future battlefield threats.



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INFORMATION REQUIREMENTS FOR BATTLEFIELD MANAGEMENT SYSTEM:
SURVEY AND PROTOTYPE EVALUATION

EXECUTIVE SUMMARY

Requirement:

New technologies offer many opportunities for improving armor system capabilities to enhance crew performance. Unfortunately, expensive technologies are often adopted into weapons systems in the absence of reliable data to support their effectiveness. The purpose of this project is to evaluate potential information items for a Battlefield Management System (BMS) at the platoon level. This project is part of a widescale effort in progress at Fort Knox to develop an effective BMS system for the maneuver force.

Procedure:

In Survey I, 30 armor officers and NCOs participated and rated 34 information items for the duty positions of platoon leader, platoon sergeant, and wingman. Their ratings were compared to those of the same 34 items by four Subject Matter Experts (SMEs). Sixteen of the former group participated in Survey II, which was a demonstration of a prototype BMS system developed by Texas Instruments.

Findings:

In Survey I, there was substantial agreement among subjects on the top 10 information items required for the duty positions, with 9 items appearing on the top 10 lists for all positions tested. There was also significant agreement between the subjects and the SMEs on the overall requirements with 6 items appearing on the top 10 of both groups. The items were (1) critical situation alert, (2) concept of operations, (3) heading reference/navigation, (4) call for fire, (5) command mission, and (6) reports (format). In Survey II subjects found the Texas Instruments prototype system to be effective, but recommended modification to the map display.

Utilization of Findings:

The knowledge gained from this project can be utilized in the development of BMS hardware and software to significantly enhance the combat effectiveness of the maneuver force.

INFORMATION REQUIREMENTS FOR BATTLEFIELD MANAGEMENT SYSTEM:
SURVEY AND PROTOTYPE EVALUATION

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INFORMATION REQUIREMENTS FOR BATTLEFIELD MANAGEMENT SYSTEM:
SURVEY AND PROTOTYPE EVALUATION

INTRODUCTION

The Battlefield Management System (BMS) is a concept designed to enhance command and control, surveillance, and fire distribution of the maneuver force. The BMS concept is designed in response to the single greatest deficiency on the battlefield today and in the future: the lack of time available to effectively coordinate combat systems and integrate battlefield information. BMS is intended as a replacement for inaccurate and inefficient methods and equipment currently used by command fighting vehicles. These methods include slow voice communications, hard copy maps with acetate and grease pencils, soldier dependent slow target acquisition, tracking and hand-off, and inaccurate land navigation (BMS, 1984).

The field artillery now uses the TACFIRE system to provide faster fire support reaction times to targets on the battlefield than the conventional method. Lessons learned from the TACFIRE led to the development of the Advance Field Artillery Test Designation System (AFATDS) (BMS, 1984). Efforts are in progress to develop an even more sophisticated system for the M1 tank and Bradley infantry fighting vehicle. An automated BMS might include an elaborate sensor array (both on board and external), an on board computer, artificial intelligence, and a display system. Information presented might include: (1) continuous real time information such as a terrain map, friendly and enemy vehicle locations, and contaminated areas; (2) real time information such as orders, identification friend or foe; (3) on call information such as operational plan, sectors of fire, adjacent unit situation; (4) logistics data; (5) maintenance data; and (6) administrative data (Blasche & Lickteig, 1983). Much research is required in BMS including what information to present, how to present it, how to train soldiers to utilize the information, and the effect of this information on overall crew performance. To date, only a few experiments have investigated the effects of some of this information on crew performance.

The US Army Human Engineering Laboratory and the German Ministry of Defense conducted an experiment evaluating the effects of presenting to tank platoon leaders real time location information on enemy and/or friendly tanks (Walker & Reiner, 1984). The experiment was conducted using the APKA system which is a mobile, computer driven, interactive command and control simulator operating in real-time. The system utilizes tank commander and driver displays, and up to 40 tanks of two different types may be allocated to opposing forces. The test consisted of 72 free-play, opposing-force battles. Three conditions were evaluated: baseline, in which the platoon operated with only the normal operational orders information; friendly, in which the real-time locations of all friendly tanks were shown to the platoon leader on a separate video screen; and friendly-enemy, in which real-time locations of all enemy and friendly tanks were displayed to the platoon leader using different symbols. Results indicated that platoons with electronic position information won more battles, but that differences in performance between the pla-

toons receiving friendly location information and the platoons receiving friendly and enemy location information were not substantial. In addition, platoon leaders failed to use the information effectively. The authors report that this failure was likely due to the lack of specific training in ways to take maximum advantage of this information.

Combat Developments Experimentation Center (CDEC) (1982) investigated the effects of providing information on threat weapon location and identification to an armor or combined arms armor platoon leader. Information was conveyed to the platoon leader by depicting the type and position of threat weapons on copies of 1:50,000 cardboard-backed photocopied maps. Positions were depicted dynamically by providing a sequence of maps showing successive positions. The friendly force consisted of four tanks and one armored personnel carrier (APC) with a TOW anti-tank weapon; the threat force consisted of one M60 tank simulating a Soviet tank (T-72) and one APC with TOW simulating a Soviet infantry fighting vehicle (BMP) with SAGGER anti-tank guided missiles. On some trials four tank decoys were used in the threat array. The threat force was in a hasty defense; the friendly force conducted a movement to contact or a hasty attack. On half the trials the friendly platoon leader received the threat location information. Battles developed more slowly and players fired fewer shots on trials with threat location information. There were indications that the information was not effectively disseminated to the platoon by the platoon leader, although platoon leaders reported the information provided a distinct advantage.

A recent Army Research Institute experiment (Jobe & Witmer, 1985) investigated the effectiveness of a display that provides target location and prioritization information to an M60A1 gunner using the Battlesight arcade style gunnery simulator. In that experiment presence or absence of the display in Phase I was combined factorially with presence or absence of the display in Phase II. Results indicated that the target location and prioritization information significantly reduced the time to complete a session of firing 50 rounds and significantly reduced the number of times the player was killed by hostile fire. Players shifted from no display in Phase I to display in Phase II showed significant improvement in performance, whereas players shifted from display to no display showed large decrements in performance. Thus, two experiments show that one aspect of BMS, target location information, would greatly assist in detecting and destroying enemy armor targets. The purpose of the present experiments was to determine which information items armor crewmen prefer in a BMS system.

SURVEY I METHOD

Subjects

The subjects for Survey I were 13 officers and 17 NCOs (9 platoon sergeants and 8 wingmen) from the Armor Officer Advanced Course, the Advanced NCO Course, the Basic NCO Course, and the 194th Armor Brigade, Fort Knox, Ky. Five of the officers had been armor company commanders. Mean time in service for the group was 7 years 9 months, with 6 years 10 months mean time in ar-

mor. Mean General Technical (GT) score of the NCOs from the Armed Services Vocational Aptitude Battery was 109.5 ± 13.29 . Over half (16) of the subjects had National Training Center experience. Summary demographic data are presented in Table 1, and complete demographic data for the subjects are presented in Appendix C.

Table 1
Summary Demographic Data

	Officers	NCOs
n	13	17
Age	26.8 years	28.8 years
Time in Service	5 years 2 months	9 years 9 months
Time in Armor	4 years 1 month	8 years 11 months
Education	13 college graduates	15 high school graduates, 2 GED
NTC Experience	6	10
GT Score	N/A	109.5

Instruments

Instruments used in Survey I included a biographical questionnaire (Appendix B) and the BMS Elements Questionnaire (Appendix C). Question 1 on the BMS Elements Questionnaire asked for ratings of a list of 34 possible BMS information items. The list was developed by a group of Subject Matter Experts (SMEs) comprised of four O-3s from the US Army Armor Center and School. The SMEs began with a list of 25 Commander's Critical Information Elements (CACDA, undated) and added information items to arrive at a final list of 34. Questions 2-5 related to the display of the information items. Questions 6 and 7 asked the subjects about handing off targets to other tanks and artillery.

Procedure

Prior to the beginning of the project, the four SMEs had rated the 34 information items according to the same criteria as the subjects (described below). Upon arriving at the survey site, the subjects were given a brief orientation to BMS by one of the four SMEs. After questions were answered, the subjects first completed the biographical questionnaire and then the BMS Elements Questionnaire. The SMEs explained any information items that were not clear to the subjects.

The information items of Question 1 were rated by the subjects according to the following scale: "Must" = must have to accomplish your mission; "need" = can accomplish your mission without it, but in a degraded mode; "good" = could use it to accomplish your mission, but can accomplish without it; and "not needed" = do not need to accomplish your mission.

Platoon leaders (n = 13) and platoon sergeants (n = 9) rated the 34 information items for each of three tanks; Platoon leader's tank, platoon sergeant's tank, and wingman's tank. Wingmen (n = 8) rated the 34 items only for their own tank position. Therefore, there were 22 raters for the platoon leader's and platoon sergeant's tanks and 30 raters for the wingman's tank.

Analysis

The following formula was used to score the responses of the subjects and SMEs to question 1: 3 = must, 2 = need, 1 = good, and 0 = not needed. The scores were then weighted and summed. Total scores for the platoon leader's tank were weighted by a factor of four, scores for the platoon sergeant's tank were weighted by a factor of three, and scores for the wingman's tank were weighted by a factor of two. Scores for the wingman's tank were also multiplied by 0.73 to account for the fact that there were 30 raters for the wingman's tank as opposed to only 22 for the other positions. The weighted score considered that an information item at the platoon leader level could be more critical to mission accomplishment than the same information at the platoon sergeant or wingman level. These weighted scores were then summed for each item to create a total weighted score which was used to rank order the 34 items for each platoon position. Then an overall weighted score was computed for the 30 subjects and was used to arrive at an overall rank order of the 34 items. This overall rank order was then correlated with a rank order from weighted scores provided by the SMEs (Siegel, 1956).

Detailed analyses were then performed on the subjects' ratings. Separate analyses were performed on the ratings for the platoon leader's tank, the platoon sergeant's tank, and the wingman's tank using the Friedman Two-Way Analysis of Variance by Ranks (Siegel, 1956). The Friedman analysis tests the null hypothesis that the rank (ordinal ratings) sums of the items are drawn from the same population. In other words, a significant result would indicate that there were differences in the rankings of the items. This analysis also calculates Kendall's coefficient of concordance which measures the agreement among rankings by the subjects. A significant coefficient would indicate that there is agreement among raters (subjects). Post hoc comparisons (Daniels, 1978) were then used to determine differences between pairs of the rank sums. That is, these comparisons would examine the scores for all possible pairs of information items to evaluate significant differences between items.

RESULTS AND DISCUSSION

Platoon Leader's Tank Ratings

There were significant differences among the rank sums of the 34 BMS information items, as supported by a significant Friedman ANOVA ($\chi^2_{(33)} = 143.62$, $p < .0001$). There was also significant agreement among raters of the platoon leader's tank as supported by a significant Kendall coefficient of concordance ($W_{(33)} = .1978$, $p < .0001$). The top ten items rated by platoon

leaders were: (1) concept of operations, (2) critical situation alert, (3) identification friend or foe, (4) call for fire, (5) heading reference/navigation, (6) command mission, (7) reports (format), (8) maintenance status, (9) enemy weapons systems, and (10) class III, V remaining. The top ten information items for each platoon position tank are shown in Table 2.

A multiple comparison procedure was applied to the rank sums of the items (Daniel, 1978), and revealed that in general there were no clearcut breaking points in the order of the ratings. The only clear distinction was that nuclear release policy was rated significantly lower than all other items. Results of the comparisons and the rank sums of all items are presented in Appendix D.

Table 2
Top Ten Information Items

Element #	Item	Rank		
		Platoon Leader's Tank	Platoon Sergeant's Tank	Wingman's Tank
11	Concept of Operations	1	1	5
12	Critical Situation Alert	2	2	1
27	Identification Friend or Foe	3	5	3
32	Call for Fire	4	8	7
31	Heading Reference/Navigation	5	6	2
8	Command Mission	6	7	8
34	Reports (Format)	7	4	10
28	Maintenance Status	8	3	18
16	Enemy Weapons Systems	9	12	6
26	Class III, V Remaining	10	10	4
5	Avenues of Approach	12	9	12
29	Target Prioritization	17	16	9

Platoon Sergeant's Tank Ratings

There were significant differences among the rank sums of the 34 BMS information items, as supported by a significant Friedman ANOVA ($\chi^2_r(33) = 165.81, p < .0001$). There was also significant agreement among the raters as supported by a significant Kendall coefficient of concordance ($W_{(33)} = .2284, p < .0001$). The top ten item rated by platoon sergeants were: (1) concept of operations, (2) critical situation alert, (3) maintenance status, (4) reports (format), (5) identification friend or foe, (6) heading reference/navigation, (7) command mission, (8) call for fire, (9) avenues of approach, and (10) class III, V remaining.

Multiple comparison procedures (Daniel, 1978) applied to the required items for platoon sergeants rank sums revealed that there were no clear cut breaking points in the order. Again, the only clear distinction was that nuclear release policy was rated significantly lower than all other items. Results of the comparisons and the rank sums of all items are presented in Appendix E.

Wingman's Tank Ratings

As with the other two platoon tank positions, there were significant differences among the rank sums of the information items required by wingmen. This finding was supported by a significant Friedman ANOVA ($\chi^2_r(33) = 225.45, p < .0001$). There was also significant agreement among raters as supported by a significant Kendall coefficient of concordance ($W_{(33)} = .2277, p < .0001$). The top ten items rated by wingmen were: (1) critical situation alert, (2) heading reference/navigation, (3) identification friend or foe, (4) class III, V remaining, (5) concept of operations, (6) enemy weapons systems, (7) call for fire, (8) command mission, (9) target prioritization, and (10) reports (format).

Multiple comparison procedures applied to the rated items for wingmen again revealed that there were no clear cut breaking points in the order. Nuclear release policy was rated last for the wingman's tank, but was not significantly different from the other items as was the case for the platoon leader's and platoon sergeant's ratings. Results of the comparisons and the rank sums of all items are presented in Appendix F.

Overall SME and Subject Rankings

The SMEs rated the seven top items equally. These were: (1) critical situation alert, (2) target prioritization, (3) target distribution/rejection, (4) heading reference/navigation, (5) call for fire, (6) free text, and (7) reports (format). Battlefield geometry was rated eighth, and concept of operations and command mission were rated equally and completed the top ten.

The subjects' overall weighted top ten were: (1) critical situation alert, (2) concept of operations, (3) identification friend or foe, (4) heading reference/navigation, (5) call for fire, (6) command mission, (7) reports (format), (8) maintenance status, (9) class III, V remaining, and (10) enemy weapons systems. Six of the ten items were common to both group's top ten ratings: (1) critical situation alert, (2) concept of operations, (3) heading reference/navigation, (4) call for fire, (5) command mission, and (6) reports (format). There was significant overall agreement between the two groups as supported by a significant Spearman rank correlation coefficient between the two groups' weighted scores $r_s(32) = .65, p < .001$. The overall weighted rankings for the two groups are presented in Appendix G.

Remaining Questions from BMS Elements Questionnaire

The remaining questions on the BMS Elements Questionnaire asked subjects about diverse areas of BMS to include: alerts to changing conditions, on-screen information, clusters of information, display format, and electronic hand off of targets.

Subjects were asked to list three to five items about which they would like to be alerted if they changed. The top five items were (1) class III, V remaining, (2) command mission, (3) critical situation alert, (4) maintenance status, and (5) adjacent unit situation. Subjects were asked to list three to five items which they would like to have constantly "on the screen". The top four rated elements were (1) class III, V remaining, (2) heading reference/navigation, (3) enemy situation, and (4) battlefield geometry.

The subjects were asked to list items that they would want displayed simultaneously. Six small clusters were identified by visual inspection. The clusters were (1) adjacent unit situation and area of operations, (2) avenues of approach and axis of advance information, (3) command mission and command G2 guidance, (4) enemy aircraft, enemy mission, enemy situation, and enemy weapons systems, (5) friendly activity and friendly unit, and (6) class III, V remaining and maintenance status.

After being given examples of informational displays for which to choose, subjects indicated that they preferred to have the majority of information elements displayed in either a graphic (map) display or alphanumeric format as opposed to bar charts and pie charts. Graphic displays were preferred for items that would give the subject an overview of the battlefield situation, such as axis of advance, adjacent unit situation, battlefield geometry, key terrain, identification friend or foe (IFF), and heading reference/navigation. These views indicate that the subjects prefer the graphic display of the BMS system to have a sophisticated map capability showing friendly and enemy vehicle locations and IFF as well as the features just described. This would allow a platoon leader or other tank commander to conceptualize the entire situation by looking at the graphic display. Thus, the TC would not have to call up several alphanumeric entries to conceptualize the situation, or not have the information at all. This would have to be accomplished without overloading the tank commander with too much information. Alphanumeric format was preferred for resource-related items such as class III, V remaining, maintenance status, assets available, and command controlled items. Preferred display format for each item is presented in Appendix G.

Subjects indicated that they would like the platoon leader to be able to electronically hand off targets to his tanks. Twelve strongly agreed, seven agreed, three were neutral, six disagreed, and one strongly disagreed. Subjects also indicated that they would like to be able to electronically hand off targets to artillery. Twenty-one strongly agreed, seven agreed, one disagreed, and one strongly disagreed. Several subjects also strongly recommended that platoon leaders not be able to slew the turret of another tank in their platoon to a target.

SURVEY II

The purpose of Survey 2 was to evaluate the information items presented by the prototype Battlefield Management System developed by Texas Instruments (TI).

METHOD

Subjects

The subjects were six officers and ten enlisted personnel who participated in Survey II after completing Survey I.

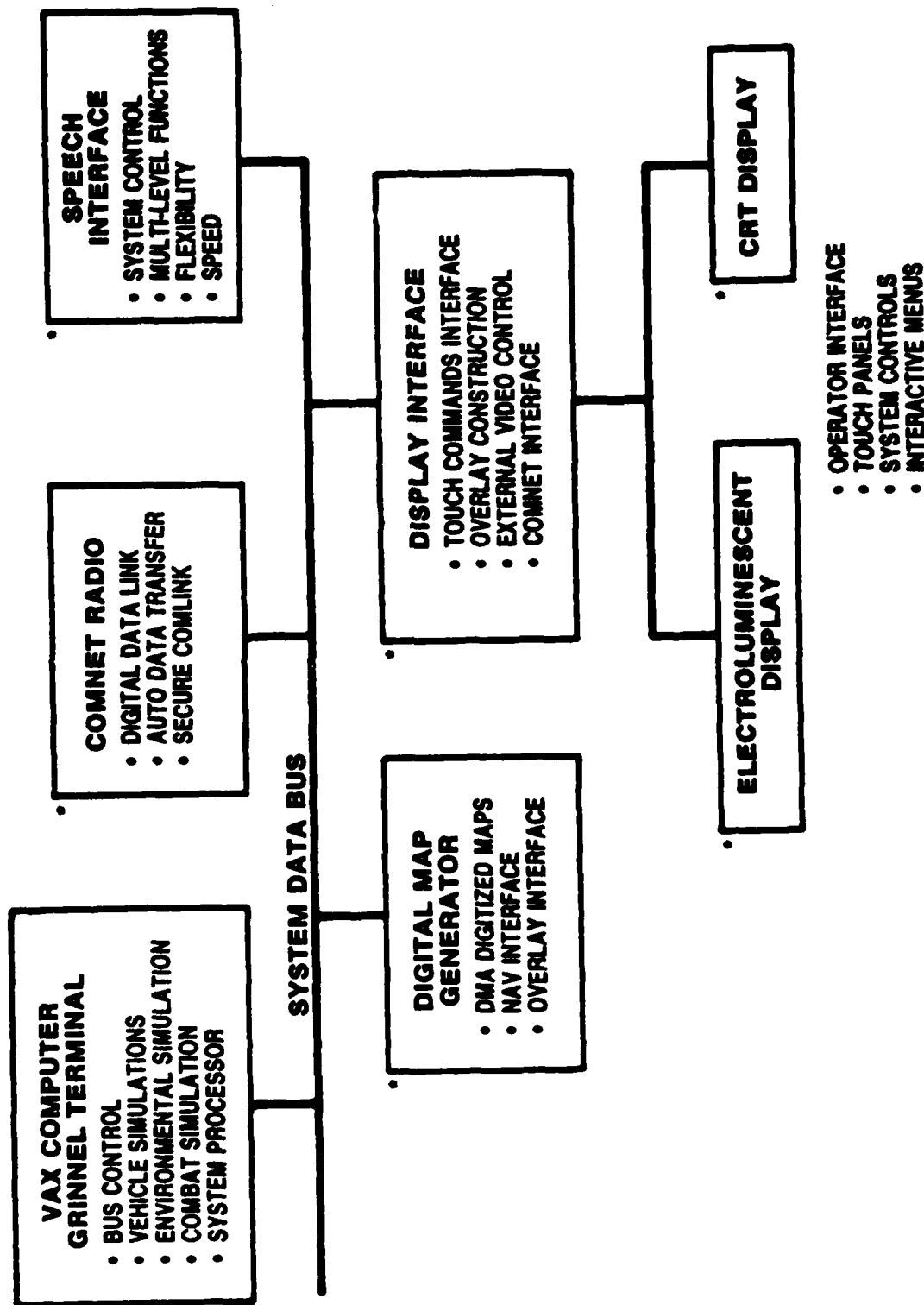
Apparatus

The TI BMS system consists of six major items (see Figure 1) which simulate potential controls and systems available to a tank commander. These items are (1) computer terminal, (2) comnet radio, (3) speech interface (voice recognition), (4) digital map generator, (5) display interface, and (6) system data base. The system is designed to provide unit leaders at the platoon, company, and battalion levels with a leadership aid in making quality decisions in less time than (see Figure 2). The system is also designed to provide more tactical decision making time to maneuver element leaders at these levels.

Procedure

The demonstration involved a 75 minute session of hands-on user evaluation. Each subject was first given a 15 minute briefing on the system by a TI representative. Each subject was then given a 15-20 minute session to learn to utilize the system and become familiar with each of its functional capabilities. This was accomplished by having a TI engineer talk the subject through the system step by step with the subject operating the controls. As part of the process, the subject enrolled his voice on the voice emulator linked to the system. The subject was then given a simple scenario which required him to move his simulated platoon across the map. He was asked to operate the system with minimal assistance from the TI engineer. He performed the following functions while using the system: (1) created an overlay, (2) issued a movement order over a route he specified, (3) assigned sectors of surveillance, (4) checked line of sight in these sectors, (5) checked the logistical and personnel status of his vehicle and platoon, (6) checked the maintenance status of his vehicle (fire control system), (7) engaged an enemy target, and (8) utilized two types of maps (relief and contour). Finally, the subject completed a survey for TI and an ARI post-test survey (Appendix H).

LAB DEMONSTRATION SYSTEM



EQUIPMENT GROUP

Figure 1



COMPETITION SENSITIVE

BATTLEFIELD LEADER'S AID

COMBAT UNITS

- TYPE
- LOC
- SITUATION

INTELLIGENCE

- ENEMY SITUATION
- TERRAIN
- TIME DISTANCE



ASSIGNED MISSION

TIME AVAILABLE

COMMAND
DECISION

COMBAT SUPPORT

- TYPE
- AVAILABILITY

LOGISTICS

- CURRENT SITUATION
- PROJECTED NEEDS
- SUPPORT ASSETS



EQUIPMENT GROUP

Figure 2

Analysis

Subject prioritization of the seven items presented by the TI system were analyzed using the Friedman two way ANOVA of Ranks (Siegel, 1956). Results of other questions on the ARI post-test questionnaire were summarized.

RESULTS AND DISCUSSION

The seven information items on the TI BMS were rated according to the criteria on the previous questionnaire, i.e., to the extent needed to accomplish the mission. There were no differences among the seven items for all three platoon positions (PL, PSG, Wingman), with no significant differences occurring on the Friedman analysis. The subjects preferences for displaying the seven items are presented in Table 3.

Table 3
Display Items and Preferred Display Format for the
Prototype TI System

<u>Item</u>	<u>Display Format</u>
Aided Navigation	Graphic Display
Friendly Positions	Graphic Display
Enemy Positions	Graphic Display
Fuel Status	Alphanumeric
Ammo Status	Alphanumeric
Warning Sensors	Graphic or Alphanumeric
Equipment Failure	Alphanumeric or Graphic Display

Subjects generally indicated that they would like to see two cluster displays—one logistical (ammo, fuel, and equipment) and one tactical (enemy and friendly positions, navigation, and warning sensors). Nine players thought the system should be portable to mount on the TC's hatch for use in reconnaissance and removable for use in unit meetings. Four thought portability was not a good idea, citing the system's sensitivity as making it prone to damage.

Subjects were evenly divided as to the method of interacting with the system, with eight preferring a touch screen capability and seven preferring a voice interaction capability. Two preferred a keypad, one keyboard, and one preferred a mouse. Fourteen of the participants recommended that the display be presented in color, especially the map navigation.

The major shortcoming of the system, as reported by the subjects, concerned the map display. They preferred to have the forward position of the tank and not compass north at top of the screen. Suggested improvements were mostly related to the map display. These suggestions included greater detail, greater resolution, and adding grid lines.

GENERAL DISCUSSION

In Survey I, subject matter experts (SMEs), platoon leaders, platoon sergeants, and wingmen completed a survey designed to rate their judgments concerning potential information items for a battlefield management system. There was generally high agreement among the duty positions and between the duty positions and SMEs as to the ratings of the items.

For all three duty positions, concept of operations, critical situation alert, and identification friend or foe ranked in the top five. Of the top ten items in the platoon leaders requirements, nine were in the top ten requirements for the platoon sergeant and wingmen positions. This would tend to support the idea that a single BMS with only minor modifications would suffice for platoon level operations. Minor differences in the ranking would appear to be due to differences in the duties required of the different duty positions. For example, the high emphasis of maintenance status (3rd) and reports format (4th) on the platoon sergeant's ratings can be attributed to the platoon sergeant's responsibilities in the areas of maintenance and logistics. The high emphasis on heading reference/navigation (2nd) on the wingmen's ratings can be attributed to the importance of maintaining accurate position heading while "on the point". The wingman's point position responsibilities are also likely to be the reason why class III, V remaining (4th) and enemy weapons systems (6th) ranked high on the list. The wingman must keep close watch on his ammo and fuel and be alert for the location enemy weapon systems.

Overall rankings between the subjects and the SMEs were also consistent. Six out of the top ten items were identical in the two groups' lists. Differences between the two lists are reflected in greater emphasis by the SMEs on offensive fighting capabilities rather than on administrative and support functions. These differences are likely attributable to the fact that the SMEs have had greater exposure to current doctrine regarding BMS concepts and potential system capabilities. SMEs are therefore more cognizant of the possible magnification of kill ratios potentiated by these higher-order capabilities in order to execute the Airland battle doctrine.

Subjects indicated that they would like for the platoon leader to have the capability to electronically hand off targets to his platoon, and to be able to electronically hand off targets to fire support assets. However, they strongly emphasized that they did not want their platoon leader to be able to automatically traverse the turret of another tank to a target or sector. The subjects indicated that the platoon leader did not have line of sight to targets the other tanks were engaging and might slew them away from a dangerous threat at an inopportune moment, thereby making a friendly tank vulnerable.

Results of the TI prototype system evaluated in Survey II indicated that the information items were rated equally for all three duty positions and that subjects were generally enthusiastic about the potential of such a system. Suggestions were made for improving the map display and included making it portable, having the map presented in color, and having the top of the map indicating forward. Subjects also preferred two clusters of display, one logistical in alphanumeric format, and one tactical in a graphic display or map format. These results taken with the preferences expressed in Survey I for the graphic display point out that the BMS system is potentially a double-edged sword. Specifically, a well-designed graphic display would aid the tank commander in the assessment or conceptualization of the battlefield at a glance, or could confuse him by, for example, having the top of the map display pointing north. In such a situation the tank commander may not utilize the system at all.

Finally, these results, taken together with the results of other studies (CDEC, 1982; Jobe & Witmer, 1985; Walker & Reimer, 1984) indicate that tank commanders and platoon leaders need training in the processing and distribution of BMS information to their platoons. Further research is needed to answer these questions, to investigate the possibility overloading the tank commander with too much information, and to field test the findings of this project.

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APPENDIX A
BIOGRAPHICAL QUESTIONNAIRE

Name _____

Date _____

Class _____

Subject # _____

1. Rank E- _____ O- _____
2. Time in Service _____ years _____ months
3. Time as TC _____ years _____ months
4. Time as Platoon Sgt _____ years _____ months
5. Time as wingman _____ years _____ months
6. Time in armor _____ years _____ months
7. Present duty position _____
8. Age _____ years
9. Education level _____
10. When did you last:
 Command a tank _____ year _____ month
 Quality a tank on Table VIII _____ year _____ month
 Pass the TCGST _____ year _____ month
11. Have you ever participated in National Training Center exercises?
 _____ yes _____ no
 If yes what was your duty position _____
12. Other experience (Reforger, Jack Frost, Empire Glacier, etc.).

APPENDIX B
BMS ELEMENTS QUESTIONNAIRE

BMS Elements Questionnaire

Name _____

Date _____

1. Rate the following 34 information elements you might need in a tank platoon in a defensive or offensive scenario.

Must = must have to accomplish your mission.

Need = can accomplish mission without it, but in a degraded mode.

Good = could use it to accomplish mission, but can accomplish without it.

Not Needed = does not need to accomplish mission.

1. Adjacent Unit Situation			
2. Area of Operations			
3. Assessment (EW + OPSEC)			
4. Assets Available			
5. Avenues of Approach (Time/Distance Factor)			
6. Axis of Advance Information			
7. Battlefield Geometry			
8. Command Mission			
9. Command/G2 Guidance (EEI)			
10. Command Controlled Items			
11. Concept of Operation			
12. Critical Situation Alert			
13. Enemy Aircraft			
14. Enemy Mission			
15. Enemy Situation (Time Distance Factor)			
16. Enemy Weapons Systems			
17. Friendly Activity			
18. Friendly Unit			
19. Intelligence Summary			
20. Key Terrain			
21. Radiation Dose Status			
22. Release Policy (Nuclear)			
23. Target Criteria			
24. Task Organization			
25. Kill Discrimination			
26. Class III, V Remaining			
27. Identification Friend or Foe			
28. Maintenance Status			
29. Target prioritization (internal)			
30. Target Distribution/Rejection			
31. Heading Reference/Navigation			
32. Call for Fire			
33. Free Text			
34. Reports (Format)			

2. List 3-5 of the above elements that you would like to be alerted to if they changed.

1.

2.

3.

4.

5.

3. List 3-5 of the above elements that you would want to have constantly "on your screen."

1.

2.

3.

4.

5.

4. List several elements that you would like to see displayed on the screen simultaneously.

Cluster 1

1

2

3

4

5

Cluster 2

1

2

3

4

5

Cluster 3

1

2

3

4

5

Cluster 4

1

2

3

4

5

Cluster 5

1

2

3

4

5

Cluster 6

1

2

3

4

5

5. What form would you like to see the above clusters displayed?

Cluster 1	Cluster 2	Cluster 3
1 graph	1	1
2 bar chart	2	2
3 alphanumeric	3	3
4 pie chart	4	4
Cluster 4	Cluster 5	Cluster 6
1	1	1
2	2	2
3	3	3
4	4	4

6. Based on your experience with armor, would you like the platoon leader to be able to electronically hand off targets to his tanks?

Strongly agree Agree Neutral Disagree Strongly disagree

Why? _____

7. Would you like to have the capability to electronically hand off targets to artillery using this system.

Strongly agree Agree Neutral Disagree Strongly disagree

Why? _____

APPENDIX C
DEMOGRAPHIC DATA

Subj #	Rank	Age Yrs	Time in Svc (mo)	Time in Armor (mo)	Educ	Time as PSG (mo)	Time as WM (mo)	Time as TC (mo)	NTC Expr	GT Score
5	O-3	28	71	48	Coll	-	-	24	No	N/A
6	O-3	27	56	56	Coll	-	-	12	Yes	N/A
7	O-3	27	62	62	Coll	-	-	18	No	N/A
8	O-3	26	45	36	Coll	-	-	24	No	N/A
9	O-1	27	98	61	Coll	-	10	15	Yes	N/A
10	E-7	29	135	135	HS	54	0	96	Yes	100
11	E-6	33	172	172	HS	27	18	99	Yes	95
12	E-6	36	177	144	GED	4	120	120	Yes	104
13	E-6	26	103	103	HS	48	12	62	Yes	116
14	E-6	35	124	124	HS+	36	48	84	Yes	138
15	O-3	26	50	50	Coll	-	-	30	No	N/A
16	O-3	26	58	58	Coll	-	-	6	Yes	N/A
17	O-3	29	60	48	Coll	-	-	24	Yes	N/A
18	E-7	31	177	177	HS	72	12	168	Yes	115
19	E-7	30	117	117	HS	28	25	72	No	104
20	O-3	27	50	50	Coll	-	-	22	No	N/A
21	O-3	29	85	42	Coll	-	-	9	Yes	N/A
22	O-3	25	70	70	Coll	-	-	52	No	N/A
23	O-3	26	44	44	Coll	-	-	24	Yes	N/A
24	E-7	38	184	87	Coll	25	0	66	No	141
25	E-6	34	169	134	HS+	77	3	120	Yes	107
26	E-5	24	60	60	GED	0	15	10	No	110
27	E-5	22	32	28	HS	0	24	5	No	112
28	O-3	26	56	17	Coll	-	-	14	No	N/A
29	E-5	23	67	67	HS	0	0	6	Yes	107
30	E-5	22	62	51	HS	0	0	5	Yes	92
31	E-5	23	60	60	HS	2	5	18	Yes	97
32	E-5	21	48	48	HS	0	8	8	No	103
33	E-7	32	159	159	HS	74	0	114	No	116
34	E-7	31	151	151	HS	44	0	54	No	105

APPENDIX D
PLATOON LEADER'S TANK RANK SUMS OF BMS INFORMATION ITEMS

Item #	Item	Rank Sum	Comparison of Means *
11	Concept of Operations	551.5	A
12	Critical Situation Alert	541.5	A
27	Identification Friend or Foe	509.0	AB
32	Call for Fire	505.5	AB
31	Heading Reference/Navigation	494.5	ABC
8	Command Mission	489.5	ABC
34	Reports (Format)	479.5	ABC
28	Maintenance Status	471.0	ABCDE
16	Enemy Weapons Systems	453.0	BCDEF
26	Class III, V Remaining	446.5	BCDEFG
7	Battlefield Geometry	444.0	BCDEFGH
5	Avenues of Approach	436.5	BCDEFGH
2	Area of Operations	431.5	BCDEFGH
1	Adjacent Unit Situation	411.0	CDEFGHI
21	Radiation Dose Status	410.5	CDEFGHI
20	Key Terrain	400.0	DEFGHIJ
29	Target Prioritization	396.5	DEFGHIJ
6	Axis of Advance Information	386.5	EFGHIJK
33	Free Text	367.0	FGHIJKL
17	Friendly Activity	360.5	GHIJKLM
13	Enemy Aircraft	357.0	HIJKLM
4	Assets Available	342.5	IJKLM
15	Enemy Situation	334.5	IJKLMN
30	Target Distribution/Rejection	329.0	IJKLMN
25	Kill Discrimination	328.5	IJKLMN
24	Task Organization	326.5	IJKLMN
3	Assessment (EW & OPSEC)	322.0	JKLMN
18	Friendly Unit	306.0	KLMN
14	Enemy Mission	287.5	LMN
9	Command/G2 Guidance (EEI)	274.5	MN
23	Target Criteria	274.5	MN
10	Command Control Items	273.0	MN
19	Intelligence Summary	253.5	N
22	Release Policy (Nuclear)	95.5	0

* Items with the same letter are not significantly different from each other.

APPENDIX E
PLATOON SERGEANT'S TANK RANK SUMS OF BMS INFORMATION ITEMS

Item #	Item	Rank Sum	Comparison of Means *
11	Concept of Operations	573.5	A
12	Critical Situation Alert	559.0	AB
28	Maintenance Status	543.0	ABC
34	Reports (Format)	504.5	ABCD
27	Identification Friend or Foe	494.0	ABCDE
31	Heading Reference/Navigation	483.0	BCDE
8	Command Mission	473.5	BCDEF
32	Call for Fire	472.5	BCDEF
5	Avenues of Approach	468.0	CDEF
26	Class III, V Remaining	466.5	CDEF
1	Adjacent Unit Situation	424.5	DEFG
16	Enemy Weapons Systems	424.5	DEFG
7	Battlefield Geometry	419.5	DEFG
20	Key Terrain	414.5	EFG
2	Area of Operations	414.0	EFG
29	Target Prioritization	414.0	EFG
30	Target Distribution/Rejection	389.5	FGH
21	Radiation Dose Status	389.0	FGH
6	Axis of Advance Information	372.0	GHI
33	Free Test	372.0	GHI
13	Enemy Aircraft	369.0	GHIJ
17	Friendly Activity	304.0	GHIJ
25	Kill Discrimination	341.5	GHIJK
15	Enemy Situation	339.0	GHIJK
4	Assets Available	315.5	HIJKL
24	Task Organization	300.5	IJKL
14	Enemy Mission	297.0	IJKL
18	Friendly Unit	293.5	IJKL
10	Command Control Items	284.5	IJKL
9	Command/G2 Guidance (EEI)	281.5	JKL
3	Assessment (EW & OPSEC)	273.5	KL
23	Target Criteria	237.5	L
19	Intelligent Summary	234.5	L
22	Release Policy (Nuclear)	87.5	M

* Items with the same letter are not significantly different from each other.

APPENDIX F
WINGMAN'S TANK RANK SUMS OF BMS INFORMATION ITEMS

Item #	Item	Rank Sum	Comparison of Means *
12	Critical Situation Alert	818.0	A
31	Heading Reference/Navigation	768.0	AB
27	Identification Friend or Foe	760.0	AB
26	Class III, V Remaining	688.5	BC
11	Concept of Operations	653.5	BCD
16	Enemy Weapons Systems	653.0	BCD
32	Call for Fire	640.5	CDE
8	Command Mission	630.5	CDEF
29	Target Prioritization	618.5	CDEF
34	Reports (Format)	618.0	CDEF
13	Enemy Aircraft	613.0	CDEF
5	Avenues of Approach	588.5	CDEF
21	Radiation Dose Status	579.5	CDEF
7	Battlefield Geometry	574.5	CDEFG
20	Key Terrain	574.0	CDEFG
30	Target Distribution/Rejection	571.0	CDEFG
25	Kill Discrimination	566.5	DEFGH
28	Maintenance Status	566.5	DEFGH
6	Axis of Advance Information	530.0	EFGHI
2	Area of Operations	511.5	FGHIJ
15	Enemy Situation	456.5	GHIJK
17	Friendly Activity	448.5	HIJK
33	Free Text	442.0	IJKL
1	Adjacent Unit Situation	429.5	IJKLM
14	Enemy Mission	421.5	IJKLM
18	Friendly Unit	411.0	IJKLM
23	Target Criteria	407.0	JKLM
3	Assessment (EW & OPSEC)	378.5	KLM
24	Task Organization	358.5	KLM
9	Command/G2 Guidance (EEI)	355.5	KLM
4	Assets Available	338.0	KLMN
19	Intelligence Summary	327.5	LMN
10	Command Control Items	320.5	MN
22	Release Policy (Nuclear)	232.0	N

* Items the same letter are not significantly different from each other.

APPENDIX G
OVERALL WEIGHTED RANKINGS OF BMS INFORMATION ITEMS BY SMEs AND SUBJECTS

SMEs			Subjects		
Item	Rank*	Subject's Display Format**	Item	Rank	
Critical Situation Alert	4	A/GD	Critical Situation Alert	1	
Target Prioritization	4	GD/A	Concept of Operation	2	
Target Distribution/Rejection	4	GD	Identification Friend or Foe	3	
Heading Reference/Navigation	4	GD	Heading Reference/ Navigation	4	
Call for Fire	4	A	Call for Fire	5	
Free Text	4	A	Command Mission	6	
Reports (Format)	4	GD/A	Reports (Format)	7	
Battlefield Geometry	8	A	Maintenance Status	8	
Concept of Operations	9.5	B/A	Class III, V Remaining	9	
Command Mission	9.5	GD	Enemy Weapons Systems	10	
Area of Operations	11.5	GD	Battlefield Geometry	11	
Friendly Unit	11.5	GD	Avenues of Approach	12	
Class III, V Remaining	13	GD/A	Target Prioritization	13	
Identification Friend or Foe	15	GD	Key Terrain	14	
Kill Discrimination	15	GD	Area of Operations	15	
Target Criteria	15	A/B	Radiation Dose Status	16	
Maintenance Status	17	GD	Adjacent Unit Situation	17	
Enemy Aircraft	18	GD/A	Enemy Aircraft	18	
		GD	Axis of Advance	19	
Avenues of Approach	19.5		Information		
Axis of Advance Information	19.5	GD	Target Distribution/ Rejection	20	
Enemy Weapons Systems	22	GD	Friendly Activity	21	
Key Terrain	22	GD	Kill Discrimination	22	
Command/G2 Guidance (EEI)	22	A	Free Text	23	
Enemy Situation	24	GD	Enemy Situation	24	
Adjacent Unit Situation	27	A	Assets Available	25	
Friendly Activity	27	GD	Friendly Unit	26	
Radiation Dose Status	27	A	Enemy Mission	27	
Task Organization	27	A	Task Organization	28	
Intelligence Summary	27	GD	Assessment (EW & OPSEC)	29	
Assessment (EW & OPSEC)	32	A	Command/G2 Guidance (EEI)	30	
Command Controlled Items	32	A	Command Controlled Items	31	
Assets Available	32	GD/A	Target Criteria	32	
Enemy Mission	32	A	Intelligence Summary	33	
Release Policy (Nuclear)	32	A	Release Policy (Nuclear)	34	

* Identical ratings for different items indicates mean rank value across these items.

** GD = graphic display, A = alphanumeric, B = bar chart

APPENDIX H
POST TEST QUESTIONNAIRE

Name _____

Date _____

1. How useful was the listed information when you played the scenario?
M = must know, N = need to know, G = good to know, and DN = don't need to know (circle one)

a. aided navigation information	M	N	G	DN
b. friendly positions	M	N	G	DN
c. enemy positions	M	N	G	DN
d. fuel status	M	N	G	DN
e. ammo status	M	N	G	DN
f. warning sensors	M	N	G	DN
g. equipment failures	M	N	G	DN

2. What additional information would you have liked to have?

a.
b.
c.
d.
e.
f.
g.

3. Which of the information elements would a wingman need to know to carry out his mission?

a. aided navigation information	M	N	G	DN
b. friendly positions	M	N	G	DN
c. enemy positions	M	N	G	DN
d. fuel status	M	N	G	DN
e. ammo status	M	N	G	DN
f. warning sensors	M	N	G	DN
g. equipment failures	M	N	G	DN

4. Which of the information elements would a platoon sergeant need to know to carry out his mission?

- | | | | | | |
|----|------------------------------|---|---|---|----|
| a. | aided navigation information | M | N | G | DN |
| b. | friendly positions | M | N | G | DN |
| c. | enemy positions | M | N | G | DN |
| d. | fuel status | M | N | G | DN |
| e. | ammo status | M | N | G | DN |
| f. | warning sensors | M | N | G | DN |
| g. | equipment failures | M | N | G | DN |

5. How would you prefer to have the information displayed? B = bar chart, G= graph, A = alphanumeric, M = map

- a. aided navigation _____
- b. friendly positions _____
- c. enemy positions _____
- d. fuel status _____
- e. ammo status _____
- f. warning sensors _____
- g. equipment failure _____

6. How would you cluster the information on one display? Describe:

7. Would you like to see the display portable? In what way?

8. How would you prefer to interact with the screen?

- a. keyboard
- b. keypad
- c. touch screen
- d. mouse
- e. voice

9. Would you like to have the display in color? Describe: